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FEATURES OF BODY COMPOSITION IN CHILDREN WITH DIFFERENT DEGREES OF OBESITY

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Abstract. *Introduction.* Bioimpedansometry is one of the methods that describes the absolute and relative amount of muscle and fat tissue, water sectors of the body. Determining the patterns of changes in the component composition of the body depending on the degree of obesity in children will improve the efficiency of therapeutic actions aimed at reducing body weight. *The aim:* to estimate the features of component composition of the body in children with varying degrees of obesity. *Materials and methods.* 152 children 7–17 years of age with obesity took part in one-time research based on the Clinic of Saint Petersburg State Pediatric Medical University: 27 people with I degree, 50 people with II degree, 42 with III degree and 33 had morbid obesity. The control group consisted of 25 healthy children without obesity. For evaluating the composition of the body, the "ABC-01 MEDASS-device" was used, St. Petersburg. The main indicators were estimated: body fat mass and it's share, lean body mass, active cell mass and it's share, skeletal muscle mass and it's share, specific basal metabolic rate, total body water and extracellular water. *Results.* The proportion of body fat mass at I–II degrees is not expressed and increases by 12–16% at III–IV degrees of obesity. The lean body mass increases with increasing the degree of obesity: I degree — 22.3% increasing; II degree — 42.1% increasing, III degree — 51.1% increasing, IV degree (morbid obesity) — 73% increasing. The indicator of Active cell mass decreases as the degree of obesity increases. The deviation of active cell mass in children with I degree of obesity was lower by 9.4% compared to the control group, with II degree — by 11.8%, with III degree — by 16.6%, with IV degree (morbid) — by 21.15%. The incidence of "sarcopenic obesity" (decrease in skeletal muscle mass and its proportion): in 25.5% of children with morbid obesity, in 20.5% with III degree and 10% with II degree. The indicator of total body water in children with I–II degrees of obesity is the same and increased by 24.7%, with III degrees — by 44.1%, with IV degrees (morbid) — by 63%. *Conclusion.* Obesity has an influence on the body composition parameters in children. These changes are different and depend on the degree of obesity. The most expressed disorders are observed in adolescents with long-term morbid obesity.

Key words: *children; obesity; degree of obesity; body composition.*

ОСОБЕННОСТИ КОМПОЗИЦИОННОГО СОСТАВА ТЕЛА У ДЕТЕЙ С РАЗЛИЧНОЙ СТЕПЕНЬЮ ОЖИРЕНИЯ

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Резюме. *Введение.* Биоимпедансометрия является одним из методов, описывающих абсолютное и относительное количество мышечной и жировой ткани, водных секторов организма. Определение закономерностей изменения компонентного состава тела в зависимости от степени ожирения у детей позволит повысить эффективность терапевтических мероприятий, направленных на снижение массы тела. *Цель:*

оценить особенности композитного состава тела у детей с различной степенью ожирения. *Материалы и методы.* Проведено одномоментное исследование, в котором приняло участие 152 ребенка в возрасте 7–17 лет с ожирением на базе клиники ФГБОУ ВО СПбГПМУ Минздрава России: 27 человек с I степенью, 50 человек со II степенью, 42 — с III степенью и 33 имели морбидное ожирение. Группу контроля составили 25 здоровых детей без ожирения. Для оценки композиционного состава тела был использован аппарат «АВС-01 МЕДАСС», г. Санкт-Петербург. Оценивали основные показатели: жировая масса тела (ЖМТ) и ее доля, безжировая (тощая) масса (БМТ) тела, активная клеточная масса (АКМ) и ее доля, скелетно-мышечная масса (СММ) и ее доля, удельный основной обмен (УОО), общая вода в организме (ОВО), внеклеточная жидкость (ВКЖ). *Результаты.* Доля ЖМТ при I–II степени не различается и увеличена на 12–16% при III–IV степени. Количество БМТ повышается с увеличением степени ожирения: I степень — превышение на 22,3%; II степень — на 42,1%, III степень — на 51,1%, IV степень (морбидное) — на 73%. Показатель АКМ по мере возрастания степени ожирения снижается: у детей с I степенью ожирения отклонение АКМ по сравнению с группой контроля было ниже на 9,4%, со II степенью — на 11,8%, с III степенью — на 16,6%, с IV степенью (морбидное) — на 21,15%. Частота встречаемости «саркопенического ожирения» (снижение СММ и ее доли): у 25,5% детей с морбидным ожирением, у 20,5% — с III степенью и 10% — со II степенью. Уровень УОО и ВКЖ не зависят от степени ожирения. Показатель ОВО у детей с I–II степенью одинаковый и увеличен на 24,7%, с III степенью — на 44,1%, с IV степенью (морбидное) — на 63%. *Заключение.* Ожирение влияет на изменение параметров композиционного состава тела у детей. Эти изменения различны и зависят от степени ожирения. Наиболее выраженные нарушения наблюдаются у подростков с длительно текущим морбидным ожирением.

Ключевые слова: *дети; ожирение; степень ожирения; композиционный состав тела.*

INTRODUCTION

According to the World Health Organization (WHO), obesity is the most common chronic disease in the world. The medical community is concerned about its progressive growth among children. This indicator in the Russian Federation has reached 27% in 2022 year [1, 2]. The importance of obesity in pediatrics is determined by the unfavorable prognosis in the form of the development of metabolic disorders and comorbid pathology [2–4]. The determination of body mass index (BMI) is recommended as a diagnostic criterion of obesity in children [5]. However, its estimation is not always sufficient because it does not reflect the ratio between the components of body weight (lean and fat mass). It is difficult to directly estimate the amount of fad tissue in the body; for this purpose, bioimpedance analysis of body composition (BIA) is used. It is a non-invasive and widely available medical diagnostic technology for analyzing the body composition (volumes of water score, lean and fat mass, active cell mass, etc.) and objective assessment of a person's nutritional status. It is based on measuring the electrical resistance of tissues (impedance) when a low-intensity electric current passes through them [6]. The use of BIA allows to create an optimal complex of effects on effective weight loss with control of markers in dynamics [7–10]. In recent years, the number of scientific publications related to body composition studies about obesity in children was increased [11–13]. Nevertheless, the issue of changes and differences in the content of bone, fat and muscle mass depending on the class of obesity has not been fully studied.

THE AIM OF THE STUDY

To evaluate the features of body composition in children with different classes of obesity.

MATERIALS AND METHODS

In the one-stage study, 152 children with obesity aged 7–17 years were examined (boys: n = 73; girls: n = 79) in clinic of FSBEI HE SPbSPMU of the Ministry of Healthcare of the Russian Federation. The class of obesity was taken as the basis for dividing patients into groups:

- Group 1 — children with I class of obesity (17.7%; n = 27);
- Group 2 — children with the II class of obesity (33%; n = 50);
- Group 3 — children with III class of obesity (27.6%; n = 42);
- Group 4 — children with IV class (morbid) of obesity (21.7%; n = 33).

The control group consisted of 25 children without obesity.

All patients underwent standard clinical and laboratory examination. To assess body composition, we used an AVS-01 MEDASS device (St. Petersburg) connected to a personal computer with installed software. The study was performed

while patients were lying on the back with the correct position of electrodes.

The main indices were evaluated in absolute numbers and percent of deviation from the norm: Body fat mass (BFM, kg), percentage of deviation from normal BFM, fraction of fat mass (BFM,%), percentage of deviation from normal BFM fraction, fat-free (lean) body mass (FFM, kg), percentage of deviation from normal BFM, active cell mass (ACM, kg), fraction of active cell mass (ACM,%), percentage of deviation from normal ACM fraction, skeletal muscle mass (SMM, kg), percentage of deviation from the normal SMM, fraction of skeletal muscle mass (SMM,%), percentage of deviation from the normal SMM fraction, specific basic metabolism rate (SBM, kcal/m per day), percentage of deviation from the normal SBM, basic metabolism rare (BM, kcal/day), total body water (TBW, kg), percentage of deviation from the norm of TBW, extracellular fluid (ECF, kg), percentage of deviation from the norm of ECF. A statistical processing was performed using the program STATISTICA 10.0 (StatSoft Inc., USA). All data are presented as median and interquartile range, because the most of studied parameters did not have an approximate-normal distribution. The Mann-Whitney test was used to assess the reliability of differences between the studied groups. A correlation analysis was performed using Spearman's criterion. The critical level of significance of differences was accepted as $p \leq 0.05$.

RESULTS AND DISCUSSION

The height values in the studied groups of children with obesity were 159.7 [120;198] cm. The physical development above average and high was found in 76% of adolescents. The body weight values in the main group were 84.3 [40.8;169] kg. The waist circumference was 100 [85;115] cm and hip circumference was 98 [91;105] cm. The distribution of subcutaneous fat tissue was uneven, with an emphasis on the abdomen. The sexual development of the children corresponded to II–V stages according to Tanner.

Fat mass

There was excess of fat mass in children with obesity compared to the control group ($p = 0.03$) (Fig. 1).

The excess of fat mass compared to the control group in children with I-II classes was in 8.4%, with III class — 12.7%, with IV class — 16.2% ($p = 0.01$).

There was a direct perfect correlation between BFM and BMI ($r = 0.95$), FFM ($r = 0.91$). A moderate correlation was found between BMI and FFM

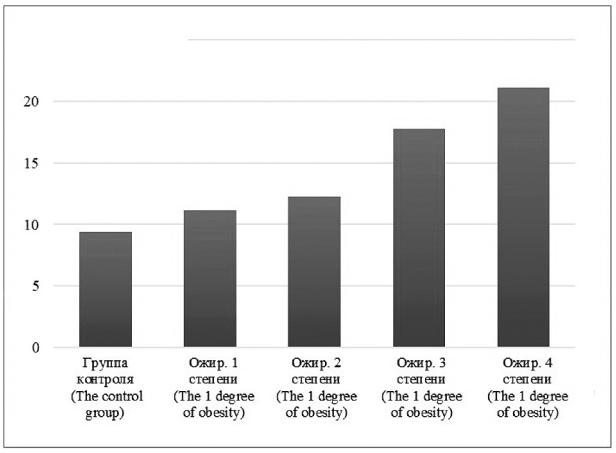

Fig. 1. Mean values of fat mass (kg) in obese children and in the control group

Рис. 1. Средние значения жировой массы (кг) у детей с ожирением и в группе контроля

Table 1. Amount of lean mass in children with different degrees of obesity

Таблица 1. Количество тощей массы у детей с различной степенью ожирения

Исследуемая группа / The study group	Среднее значение количества тощей массы, кг / The mean of lean mass, kg	Превышения БМТ по сравнению с группой контроля, % / The excesses of the lean body mass compared to the control group, %
Группа контроля / The control group	40,25	
Ожирение I степени / The I degree of obesity	49,22	22,3%
Ожирение II степени / The II degree of obesity	57,19	42,1%
Ожирение III степени / The III degree of obesity	60,82	51,1%
Ожирение IV степени / The IV degree of obesity	69,63	73%

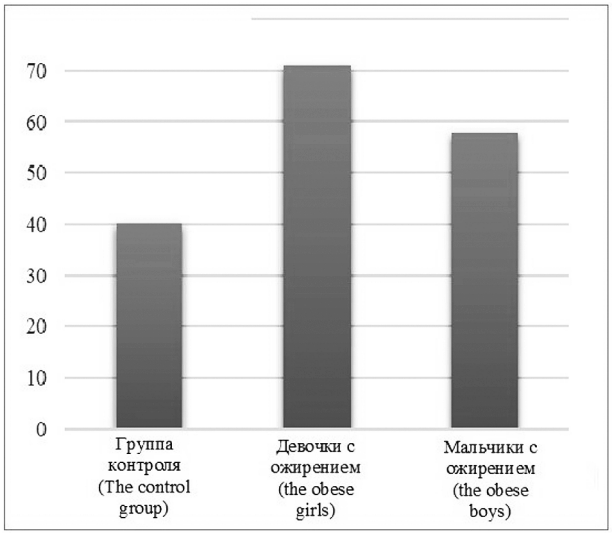

Fig. 2. Mean values of lean mass percentage (kg) in obese girls and boys and in the control group

Рис. 2. Средние значения доли тощей массы (кг) у девочек и мальчиков с ожирением и в группе контроля

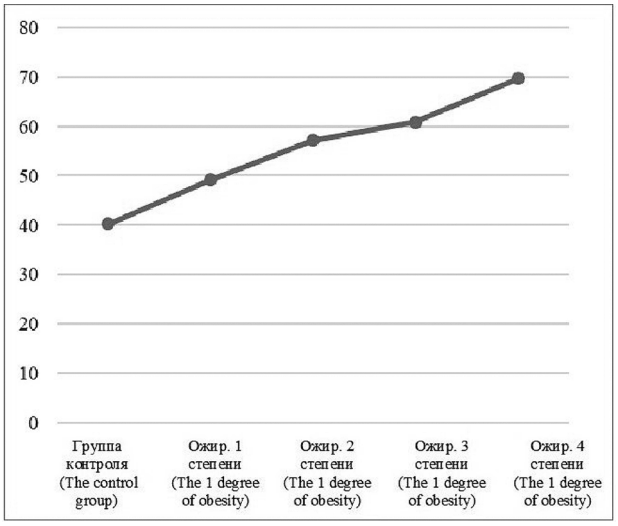

Fig. 3. Level of deviation of lean mass percentage (%) in children with different degrees of obesity

Рис. 3. Уровень отклонения доли тощей массы (%) у детей с различной степенью ожирения

(r = 0.61), which indicates that the increase in BMI in overweight and children with obesity is mainly due to an increase in BFM. To a lesser extent BMI in children with obesity is affected by FFM.

Lean body mass (fat-free mass)

The mean values of FFM in children in the studied groups are presented in Table 1.

A statistically significant excess of FFM was found in 30% of adolescents (13–17 years old) with obesity (p = 0.0001). There was a significant difference in the value of FFM excess. It was 72,9% in girls and 41,3% in boys (p = 0.02) (Figure 2).

The percentage of FFM deviation was not the same in groups of different classes of obesity, in all groups it was exceeded: in group 1 — 22.3%; in group 2 — 42.1%; in group 3 — 51.1% and in group 4 — 73% (p = 0.003) (Figure 3).

Active cell mass

Active cell mass (ACM) includes actively metabolizing muscle cells, cells of internal organs, and nervous tissue. The ideal proportion of ACM is 50–56% [6]. The importance of maintaining normal ACM is confirmed by a number of studies, according to them, the ACM is a needed part to lose a fat mass in the process of reducing body weight.

A decrease in the number of metabolically active cells leads to a decrease in the metabolic rate and causes a constant feeling of hunger, signaling that the cells of the body are undernourished despite the large amount of energy scores in the body [2].

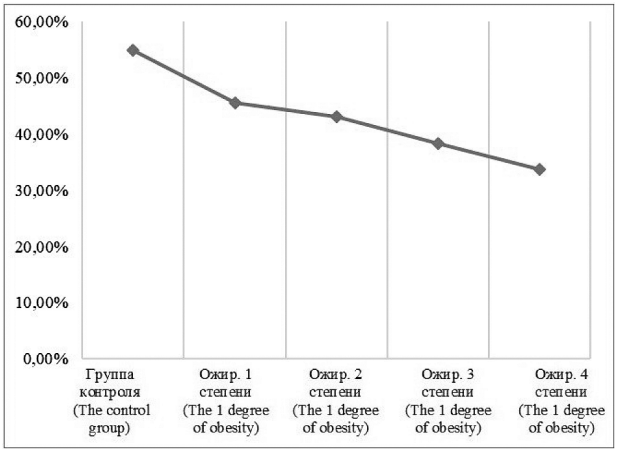

Fig. 4. Dependence of ACM level on the degree of obesity

Fig. 4. Dependence of ACM level on the degree of obesity

If we think that children with obesity experience a greater sense of hunger compared to children with normal body weight, it can be argued that low levels of ACM are a serious problem in the weight loss process.

There is a tendency: the ACM decreases if the degree of obesity increases. In children with class I of obesity, the deviation of ACM compared to the control group was lower by 9.4%, with class II — by 11.8%, with class III — by 16.6%, with class IV — by 21.15% (p = 0.003) (Fig. 4).

Skeletal muscle mass

In 56% of the examined children with obesity, a decrease in the level of SMM and its fraction was detected (p ≤ 0.05). A normal fraction of SMM was

found in 29% and in 15% was increased ($p \leq 0,05$). The condition of progressive loss of muscle mass is most studied in elderly patients and children with oncologic diseases, cerebral palsy, in the postoperative period and is called "sarcopenia" [9, 10]. The "Sarcopenia" on the background of obesity in children is a poorly studied problem and deserves a special attention [10]. The frequency of "sarcopenia" increased with increasing of class of obesity: a 25.5% of the examined patients with decreased SMM had IV class of obesity (morbid), 20.5% — III class and 10% — III class (Fig. 5). The 88.1% of the examined children with low SMM had a long (> 5 years) course of obesity diagnosed at an early age, progressing in puberty.

Specific basic metabolism

When evaluating the SBM, it was found that in the group of patients with obesity the values were higher than in the control group. A study of correlations demonstrates a direct relationship between the level of ACM in the main group of children with obesity and the level of SBM in this group ($r = 0.84$). A weak direct correlation ($r = 0.27$) was found between the level of SBM and BFM, indicating an increase in SBM in children with obesity due to an increase in the number of metabolizing cells rather than adipose tissue. No statistically significant differences in the level of SBM depending on the degree of obesity were found.

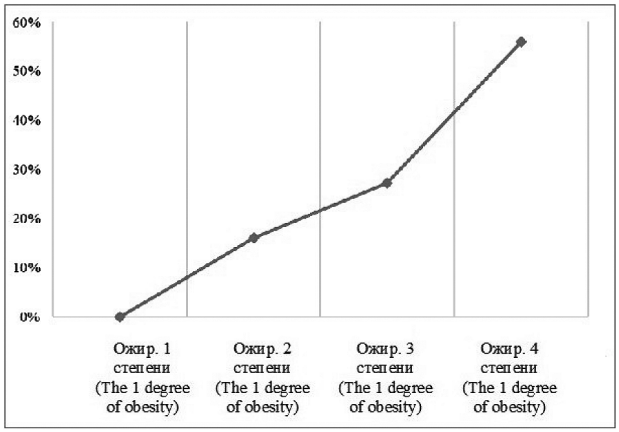

Fig. 5. Frequency of "sarcopenia" among children with different degrees of obesity

Рис. 5. Частота «саркопении» среди детей с различной степенью ожирения

Total body water

In 100% of cases, an excess of TBW was found in children with obesity compared to children of the control group (Table 2).

If the class of obesity increases, there are an increase in TBW, in girls largely than in boys (70.2 and 41%, respectively) ($r = 0.91$, $p = 0.001$). In children with I–II classes it was by 24.7%, with III class — by 44.1%, with IV class — by 63% ($r = 0.92$, $p = 0.002$). There was a difference in the degree of TWO excess between boys and girls with IV class of obesity by 39.7 and 67.3%, respectively ($p = 0.0002$).

According to a number of researchers, the specific weight of water in adipose tissue is much lower than in muscle tissue [6]. Thus, the muscle mass makes the greatest contribution to the increase in the level of TWO, which is confirmed by the correlation between the ACM and value of total water ($r = 0.9$).

Extracellular fluid

The change of ECF value was found in children with obesity of high school age only (15-17 years old). The decrease in the amount of ECF was found in 26% of children with III-IV classes of obesity and increase — in 6.2% ($p = 0.001$).

CONCLUSION

Obesity makes a significant contribution to changes in body composition in children. The

Table 2. Mean values of total body water in obese children compared to the control group

Таблица 2. Средние значения ОВО у детей с ожирением по сравнению с группой контроля

Исследуемая группа / The study group	Среднее значение уровня ОВО, кг / Mean values of total body water, kg	Превышения по сравнению с группой контроля, % / The excesses compared to the control group, %
Группа контроля / The control group	44,3	
Ожирение I степени / The I degree of obesity	54,75	23,61
Ожирение II степени / The II degree of obesity	55,24	24,7
Ожирение III степени / The III degree of obesity	63,84	44,11
Ожирение IV степени / The IV degree of obesity	72,21	63

changes are different and depend on the class of obesity. The most pronounced disorders are observed in adolescents with long-term morbid obesity.

1. The proportion of BFM is not different in I–II classes of obesity and increased by 12–16% in III–IV classes.

2. The amount of FFM increases with increasing of class of obesity: in the I class, it exceeded by 22.3%, II class — 42.1%, III class — 51.1% and III class (morbid) — 73%.

3. The ACM value decreases with increasing of the class of obesity: in children with I class of obesity, the deviation of ACM compared to the control group was lower by 9.4%, with II class — by 11.8%, with III class — by 16.6%, with IV class (morbid) — by 21.15%.

4. The frequency of "sarcopenic obesity" (decreased SMM and its proportion): in 25.5% of children with morbid obesity, in 20.5% with III class and in 10% with II class.

5. The levels of SBM and ECF are independent of the class of obesity.

6. The TBW in children with I-II classes of obesity is the same and increased by 24.7%, with III class — by 44.1%, with IV class (morbid) — by 63%.

ADDITIONAL INFORMATION

Author contribution. Thereby, all authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to be accountable for all aspects of the study.

Competing interests. The authors declare that they have no competing interests.

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Consent for publication. Written consent was obtained from the patient's legal representatives for publication of relevant medical information within the manuscript.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

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Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

Источник финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования.

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